

WHAT IS CLAIMED IS:

1. A cathode material for a rechargeable electrochemical cell, said cell also comprising an anode and an electrolyte, the cathode comprising a compound having the formula LiMPO_4 , where M is at least one first-row transition-metal cation.

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2. The cathode material of claim 1, where M is further defined as being selected from the group consisting of Mn, Fe, Co, and Ni.

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3. The cathode material of claim 1, where M is further defined as being a combination of cations, at least one of which is selected from the group consisting of Mn, Fe, Co and Ni.

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4. The cathode material of claim 3, where M is $\text{Fe}_{1-x}\text{Mn}_x$ or $\text{Fe}_{1-x}\text{Ti}_x$ and $0 < x < 1$.

5. The cathode material of claim 2, wherein the cathode material has the formula LiFePO_4 .

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6. A cathode material for a rechargeable electrochemical cell, said cell also comprising an anode and an electrolyte, the cathode material comprising a rhombohedral NASICON material having the formula $\text{Y}_x\text{M}_2(\text{PO}_4)_3$, where M is at least one first-row transition-metal cation and $0 \leq x \leq 5$ and Y is Li or Na.

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7. The cathode material of claim 5, where M is selected from the group consisting of Fe, V, Mn, and Ti.

8. The cathode material of claim 7, wherein the cathode material has the formula $\text{Li}_{3+x}\text{Fe}_2(\text{PO}_4)_3$, where $0 \leq x \leq 2$.

9. The cathode material of claim 7, wherein the cathode material has the formula $\text{Li}_3\text{Fe}_2(\text{PO}_4)_3$.

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10. The cathode material of claim 7, having the formula $\text{Li}_{1+x}\text{Ti}_2(\text{PO}_4)_3$.

11. The cathode material of claim 7, having the formula $\text{Li}_2\text{FeTi}(\text{PO}_4)_3$.

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LiNb
12. The cathode material of claim 7, having the formula $\text{Li}_x\text{TiNb}(\text{PO}_4)_3$, where $0 \leq x \leq 2$.

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13. The cathode material of claim 7, having the formula $\text{Li}_{1+x}\text{FeNb}(\text{PO}_4)_3$, where $0 \leq x \leq 2$.

14. The cathode material of claim 7, prepared by the process comprising the steps:

- (a) preparing $\text{Na}_2\text{Fe}_2(\text{PO}_4)_3$; and
- (b) contacting said $\text{Na}_2\text{Fe}_2(\text{PO}_4)_3$ with a molten lithium salt, such that an ionic exchange reaction occurs.

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15. The cathode material of claim 7, prepared by a direct solid state reaction.

16. A cathode material for a rechargeable electrochemical cell, said cell also comprising an anode and an electrolyte, the cathode material comprising a rhombohedral NASICON material having the formula $\text{Y}_x\text{M}_2(\text{PO}_4)_y(\text{XO}_4)_{3-y}$, where $0 < y \leq 3$, M is a transition-metal atom, $0 \leq x \leq 5$, Y is Li or Na, and X = Si, As, or S.

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17. The cathode material of claim 16, wherein the cathode material has the formula $\text{Li}_{1+x}\text{Fe}_2(\text{SO}_4)_2(\text{PO}_4)$, where $0 \leq x \leq 2$.

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18. The cathode material of claim 17, prepared by the process comprising the steps:

- (a) preparing an aqueous solution comprising FeCl_3 , $(\text{NH}_4)_2\text{SO}_4$, and LiH_2PO_4 ;
- (b) evaporating the solution to obtain dry material; and

(c) heating the dry material to about 500°C.

19. A cathode material for a rechargeable electrochemical cell also comprising an anode and an electrolyte, the cathode comprising a rhombohedral NASICON material having the formula $A_{3-x}V_2(PO_4)_3$, where A may be Li, Na or a combination thereof and $0 \leq x \leq 2$.

20. The cathode material of claim 19, wherein the cathode material has the formula $Li_{2-x}NaV_2(PO_4)_3$, where $0 \leq x \leq 2$.

10 21. The cathode material of claim 19, prepared by the process comprising the steps:

- preparing $Na_3V_2(PO_4)_3$; and
- contacting said $Na_3V_2(PO_4)_3$ with a molten lithium salt, such that an ionic exchange reaction occurs.

15 22. The cathode material of claim 19, prepared by a direct solid-state reaction.

23. A secondary battery comprising an anode, a cathode and an electrolyte, said cathode comprising an ordered olivine compound having the formula $LiMPO_4$, where M is at least one first-row transition-metal cation.

20 24. The battery of claim 23, where M is further defined as being selected from the group consisting of Mn, Fe, Co, and Ni.

25 25. The battery of claim 23, where M is further defined as being a combination of cations, at least one of said cations being selected from the group consisting of Mn, Fe, Co, and Ni.

26. The battery of claim 25, wherein M is $Fe_{1-x}Mn_x$ or $Fe_{1-x}Ti_x$, where $0 \leq x \leq 1$.

27. A secondary battery comprising an anode, a cathode and an electrolyte, said cathode comprising a rhombohedral NASICON material having the formula $Y_xM_2(PO_4)_3$, where M is at least one first-row transition-metal cation and $0 \leq x \leq 5$ and Y is Li or Na, other than $Li_{2+x}FeTi(PO_4)_3$.

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28. The battery of claim 27, where M is selected from the group consisting of Fe, V, Mn, and Ti.

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29. The battery of claim 28, wherein the cathode material has the formula $Li_{3+x}Fe_2(PO_4)_3$, where $0 \leq x \leq 2$.

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30. The battery of claim 29, wherein the cathode material has the formula $Li_3Fe_2(PO_4)_3$.

31. The battery of claim 28, wherein the cathode material has the formula $Li_2FeTi(PO_4)_3$.

32. The battery of claim 28, wherein the cathode material has the formula $Li_xTiNb(PO_4)_3$, where $0 \leq x \leq 2$.

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33. The battery of claim 28, wherein the cathode material has the formula $Li_{1+x}FeNb(PO_4)_3$, $0 \leq x \leq 2$.

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34. A secondary battery comprising an anode, a cathode and an electrolyte, said cathode comprising a rhombohedral NASICON material having the formula $Y_xM_2(PO_4)_y(XO_4)_{3-y}$, where $0 < y \leq 3$, M is a transition-metal atom, $0 \leq x \leq 5$, Y is Li or Na, and X = Si, As, or S.

35. The battery of claim 34, wherein said cathode material has the formula $Li_{1+x}Fe_2(PO_4)(SO_4)_2$, where $0 \leq x \leq 2$.

36. A secondary battery comprising an anode, a cathode and an electrolyte, said cathode comprising a rhombohedral NASICON material having the formula $A_{3-x}V_2(PO_4)_3$, where A may be Li, Na or a combination thereof and $0 \leq x \leq 2$.

5 37. The battery of claim 36, wherein the cathode material has the formula $Li_{2+x}NaV_2(PO_4)_3$, where $0 \leq x \leq 2$.

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